REPORT No. 428

WIND-TUNNEL TESTS OF A CLARK Y WING WITH A NARROW AUXILIARY AIRFOIL IN DIFFERENT POSITIONS

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SUMMARY

Aerodynamic force tests were made on a combination of a Clark Y wing and a narrow auxiliary airfoil to find the best location of the auxiliary airfoil with respect to the main wing. The auxiliary was a highly cambered airfoil of medium thickness having a chord 14.5 per cent that of the main wing. It was tested in 141 different positions ahead of, above, and behind the nose portion of the main wing, the range of the test points being extended until the best aerodynamic conditions were covered.

A range of positions was found in which the combination of main wing and auxiliary gave substantially greater aerodynamic efficiency and higher maximum lift coefficients (based on total area) than the main Clark Y wing alone. In the optimum position tested, considering both the maximum lift and the speed-range ratio, the combination of main wing and auxiliary gave an increase in the maximum lift coefficient of 32 per cent together with an increase in the ratio $C_{L_{max}}/C_{D_{min}}$ *of 21 per cent of the respective values for the main Clark Y wing alone.*

INTRODUCTION

In an effort to provide means for obtaining lower landing speeds and greater speed ranges, many devices have been developed for increasing the maximum lift without excessive increase of the drag. These devices include pilot planes, slots, flaps, etc., most of which have movable parts entailing a certain amount of complication. In this field recent tests have been made by the National Advisory Committee for Aeronautics on a Clark Y airfoil with Handley Page type slots, in which the slat portion was tested in a large number of different positions to determine the best. (Reference 1.) A series of tests has also been made to develop a fixed slot for the same airfoil giving a reasonably high maximum lift coefficient with the lowest possible minimum drag coefficient and having no movable parts. (Reference 2.)

The present investigation consists of further tests of the same type on a Clark Y wing with a narrow auxiliary airfoil tested in a sufficient number of locations and angular positions with respect to the main wing to determine the optimum one. These tests, as well as those previously mentioned, were made in the N.A.C.A. 5-foot vertical tunnel under the same conditions

In addition, these tests were made at the same air speed and on a model having the same chord as that used in a standard series of controllability and stability tests (reference 4) which are being made in the N.A.C.A. 7 by 10 foot tunnel. Aileron tests on a wing with the auxiliary airfoil in the best position will be included in the series.

APPARATUS AND METHODS

Wind tunnel.—The N.A.C.A. vertical wind tunnel, which has an open jet 5 feet in diameter and a closed return passage, is described in detail in reference 3.

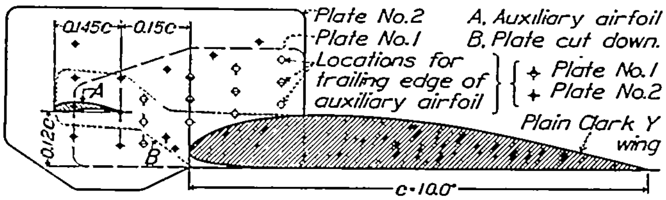
A "reflection plane" and half-span model were used because a full-span wing of aspect ratio 6 and 10-inch chord could not be tested in the vertical tunnel.

The drag forces were transmitted from the wing by two fine wires to a platform balance above the tunnel. The lift forces were transmitted by a system of bell cranks and rigid rods to two platform balances mounted on the tunnel test floor. A detailed description of the arrangement may be found in reference 1.

Models.—The main wing, which had a Clark Y section, had previously been used in the fixed-slot tests of reference 2, and for the present tests the slot was filled with "Plasticine." The auxiliary airfoil, because of its small size, was made of aluminum alloy. It was a highly cambered airfoil of medium thickness ratio (12 per cent) and had a chord 14.5 per cent of the chord of the main wing. It had previously been used during one stage of the fixed-slot development. For the present tests it was supported on the main wing by thin metal plates at each end and by a small bracket at midspan. The details of the supporting plates and the ordinates of both main and auxiliary airfoils are given in Figure 1.

Tests.—The tests were made with the trailing edge of the auxiliary airfoil in 24 different locations with respect to the main wing. At each location of the trailing edge tests were made with the chord line of the auxiliary at several different angles, δ, with respect to the chord line of the main wing, making 141 positions in all. The first arrangement (pl. 1, fig. 1) included only 12 locations of the trailing edge. Others were then added until the optimum was found.

In the main series of tests the lift and drag were measured at various angles of attack for each position of the auxiliary. Readings were taken at 1° intervals to cover the region of the minimum drag and maximum lift coefficients and several points were taken in between to determine the shape of the lift and drag curves. Pitching moments, which required a slight change in the balances, were also measured for a few of the better positions of the auxiliary airfoil.



AUXILIARY ORDINATES

Stations per cent chord [1]	Upper, per cent chord [1]	Lower, per cent chord [1]
0.00	2.88	2.88
1.25	5.40	1.09
2.50	6.48	.65
5.00	8.02	.28
7.50	9.11	.08
10.00	9.96	.00
15.00	11.34	.12
20.00	12.29	.44
30.00	13.35	1.46
40.00	13.42	3.08
50.00	12.60	4.78
60.00	11.12	5.63
70.00	9.15	5.79
80.00	6.68	4.68
90.00	3.95	2.67
95.00	2.51	1.32
100.00	1.13	0

CLARK Y ORDINATES

Stations, per cent chord	Upper, per cent chord	Lower, per cent chord
0.00	3.50	3.50
1.25	5.45	1.93
2.50	6.50	1.47
5.00	7.90	.93
7.50	8.85	.63
10.00	9.60	.42
15.00	10.69	.15
20.00	11.36	.03
30.00	11.70	0
40.00	11.40	0
50.00	10.52	0
60.00	9.15	0
70.00	7.35	0
80.00	5.22	0
90.00	2.80	0
95.00	1.49	0
100.00	.12	0

[1] Auxiliary chord.

FIGURE 1.—Clark Y wing with auxiliary airfoil and mounting plates. (Best position for the auxiliary airfoil is shown)

The tests were made at a dynamic pressure of 16.37 pounds per square foot, which corresponds to an air speed of 80 miles per hour under standard atmospheric conditions at sea level. The Reynolds Number with the above test conditions and the main wing chord of 10 inches was 609,000, which is about one-third of that for an ordinary small airplane while landing.

RESULTS

The results are given in terms of the standard absolute coefficients of lift and drag, and center of pressure (C_L, C_D, and *c.p.*), the latter referring to the chord of the main wing. In the computation of these coefficients the total area of the main wing plus the auxiliary was used.

Curves of the lift and drag coefficients plotted against the angle of attack for all positions of the auxiliary with respect to the main wing are given in Figures 2 to 25, inclusive. Each figure includes the results for the various angles of the auxiliary at one location of its trailing edge, and also the curves for the main wing alone.

The values of $C_{L_{max}}$, $C_{D_{min}}$, and the angle of attack for $C_{L_{max}}$, are given in Table I along with the values of the ratios $C_{L_{max}}/C_{D_{min}}$ and $(C_{L_{max}})^2/C_{D_{min}}$ for each position of the auxiliary airfoil.

For facilitating the selection of the position of the auxiliary airfoil giving the highest values of $C_{L_{max}}$, contours of equal values of the maximum lift coefficient are given in Figure 26. The value at any point represents the maximum that can be obtained with any angular position δ. Similar contour charts for the equal values of the ratios $C_{L_{max}}/C_{D_{min}}$ and $(C_{L_{max}})^2/C_{D_{min}}$ are given in Figures 27 and 28, respectively.

Curves of the center of pressure plotted against angle of attack are given for a few of the better positions of the auxiliary in Figures 7 and 8. The values for the Clark Y wing alone are also included for comparison.

Effect of supporting plates.—The accuracy of the present tests was about the same as that of the previous tests with the same set-up (references 1 and 2) except for the effect of the rather large end plates which supported the auxiliary airfoil. To find the effect of the plates on the results, the tests with one of the better locations were repeated with the supporting plates cut down (fig. 1, dotted lines). The results of these tests showed that the effect on the drag and center of pressure was within the limits of experimental error and therefore negligible. The effect on the lift coefficients was noticeable but small, the values being about 2 per cent greater with the large end plates. This value was considered sufficiently small to be neglected in the present comparisons.

DISCUSSION

The contour lines in Figure 26 indicate that the position of the auxiliary airfoil giving the highest value of the maximum lift coefficient was that with the trailing edge about 3 per cent *c* ahead of the nose and 10 per cent *c* above the chord line of the main wing, *c* being the main-wing chord. The highest value actually measured ($C_L = 1.812$) was found at the point with the trailing edge of the auxiliary 5 per cent *c* ahead of the nose and 6.5 per cent *c* above the chord line of the main wing, with δ equal to $-30°$. Another region which gave a high maximum lift coefficient was in the neighborhood of 17 per cent *c* ahead of the nose and 12 per cent *c* above the chord line, where the highest value of $C_{L_{max}}$ was about 1.73. The highest actual test point in this region was 15 per cent *c* ahead of the nose and 12 per cent *c* above the chord line with δ equal to $-2.5°$, an angle which is obviously better for obtaining a low value of $C_{D_{min}}$.

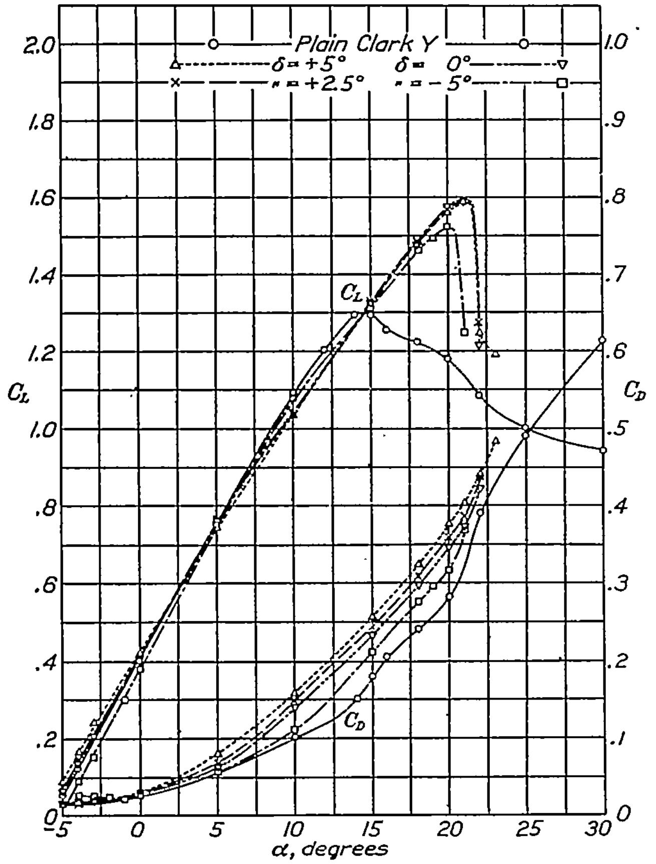


FIGURE 2.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 25 per cent chord ahead of leading edge and 6.5 per cent chord above chord line of main wing

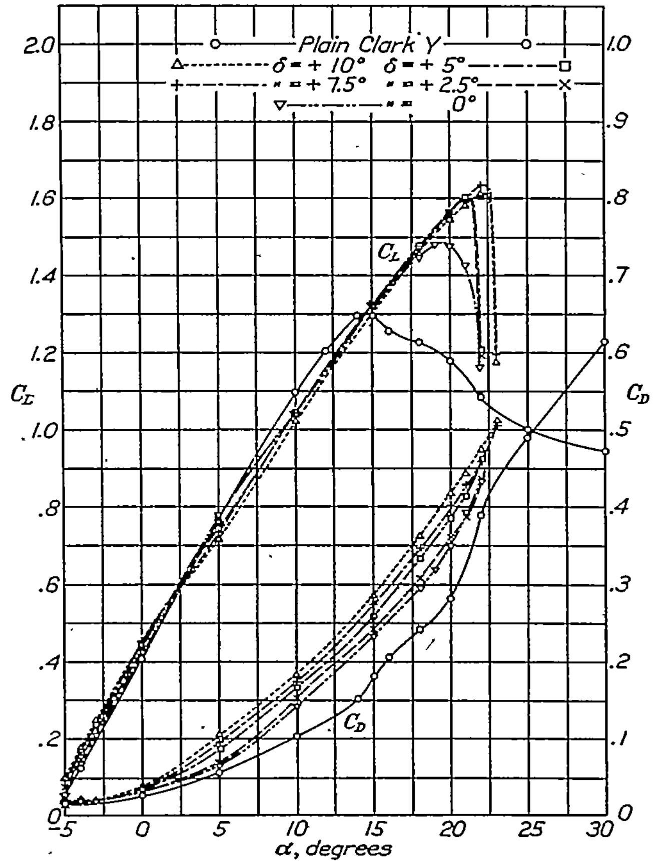


FIGURE 3.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 25 per cent chord ahead of leading edge and 13 per cent chord above chord line of main wing

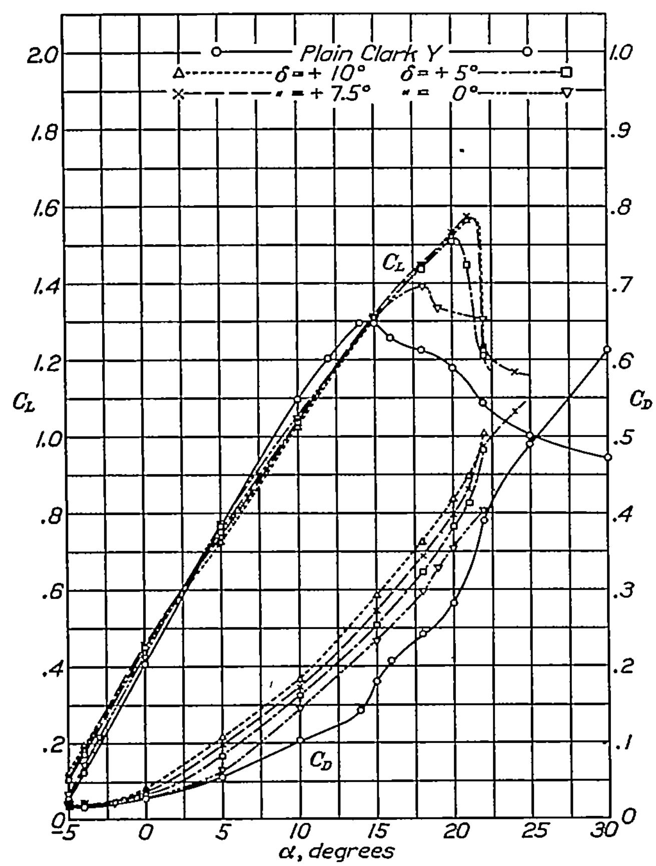


FIGURE 4.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 25 per cent chord ahead of leading edge and 19.5 per cent chord above chord line of main wing

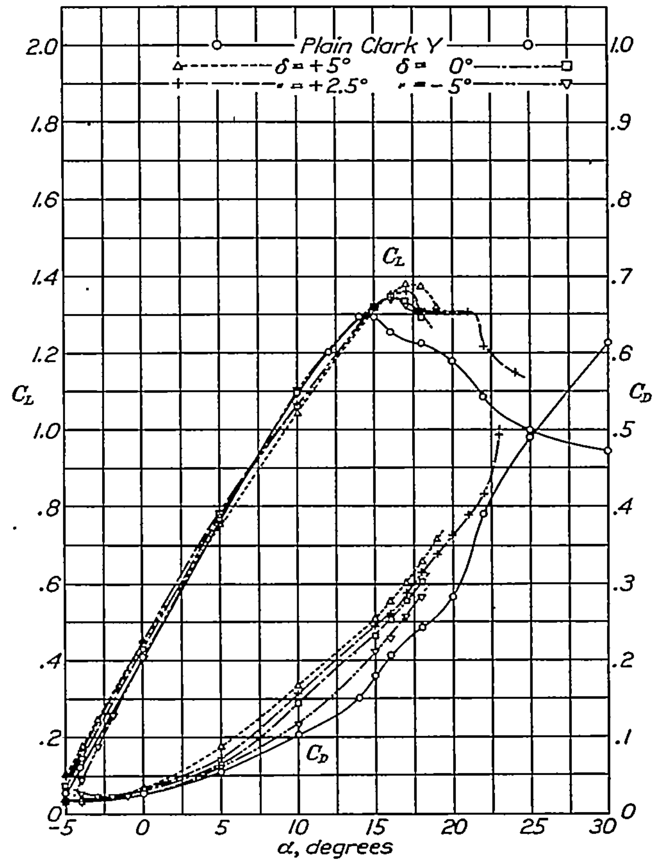


FIGURE 5.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 25 per cent chord ahead of leading edge and 27 per cent chord above chord line of main wing

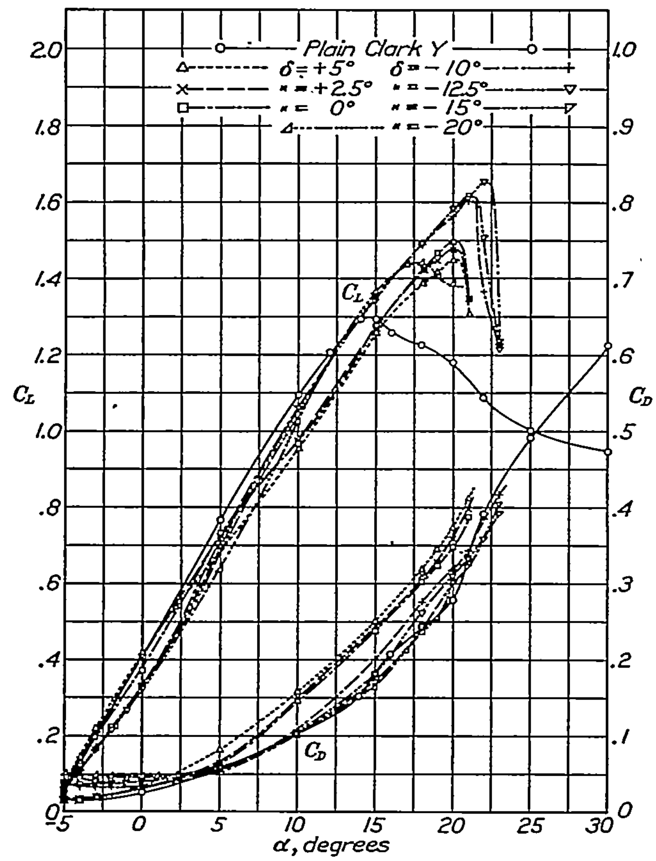


FIGURE 6.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 15 per cent chord ahead of leading edge and 4.5 per cent chord above chord line of main wing

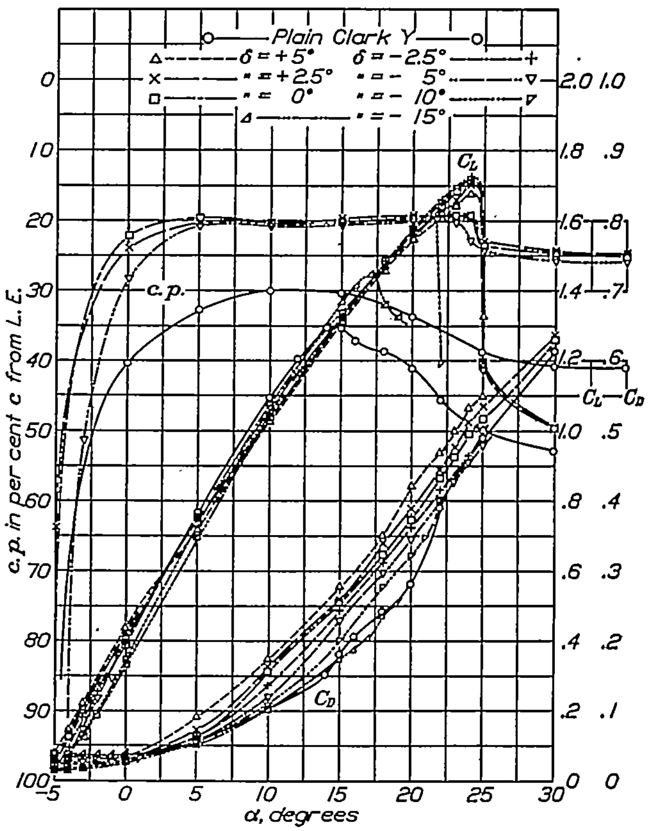


FIGURE 7.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 15 per cent chord ahead of leading edge and 12 per cent chord above chord line of main wing

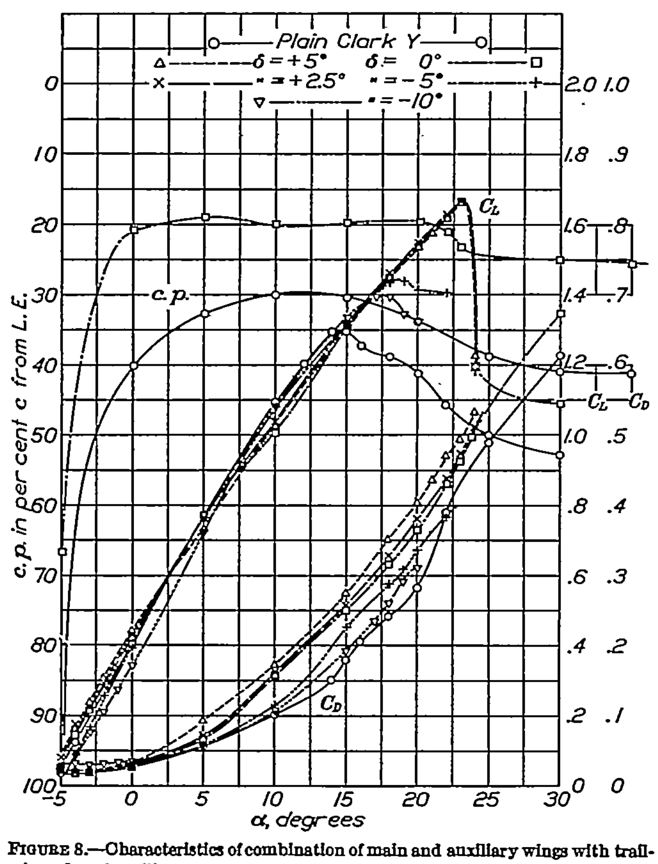


FIGURE 8.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 15 per cent chord ahead of leading edge and 19.5 per cent chord above chord line of main wing

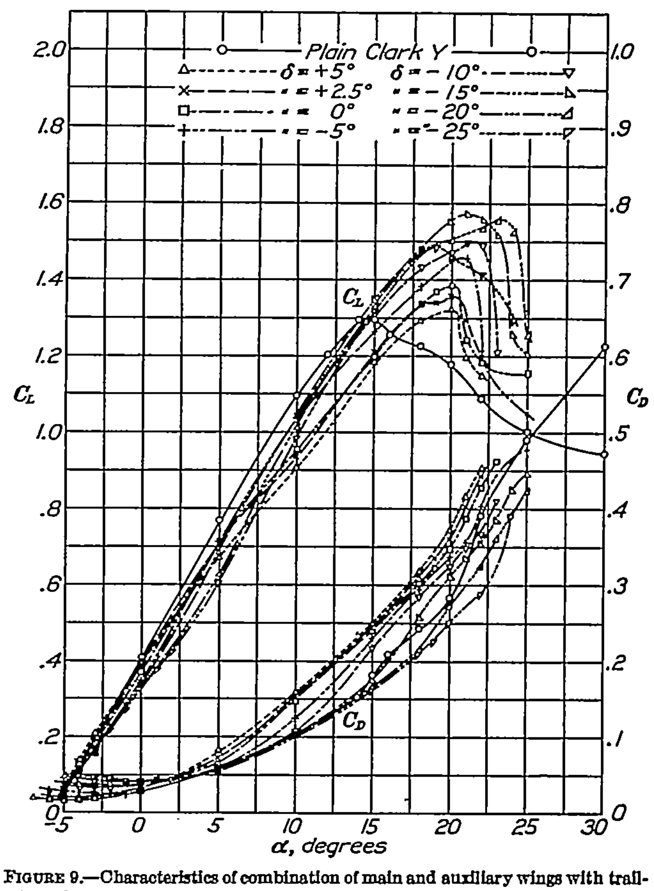


FIGURE 9.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 10 per cent chord ahead of leading edge and 5 per cent chord above chord line of main wing

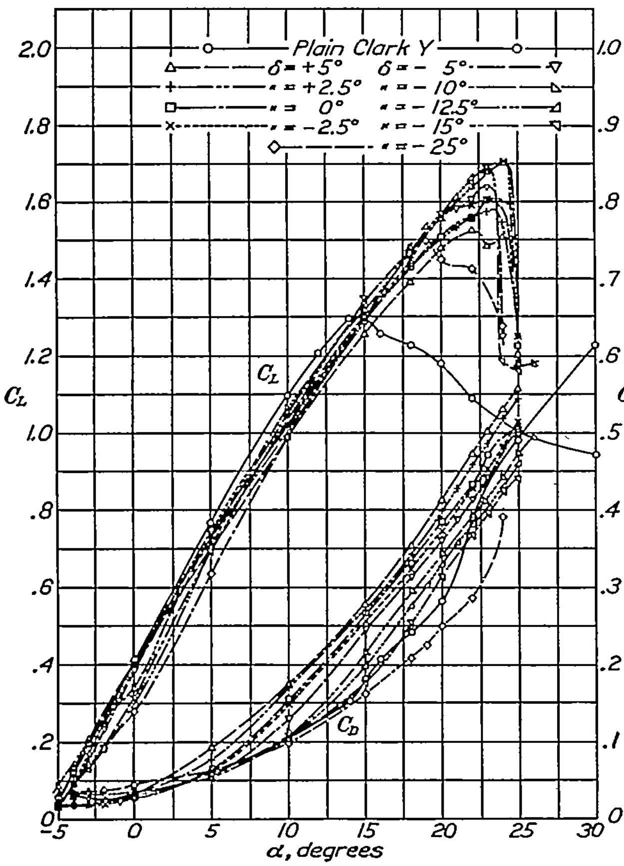


FIGURE 10.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 10 per cent chord ahead of leading edge and 10 per cent chord above chord line of main wing

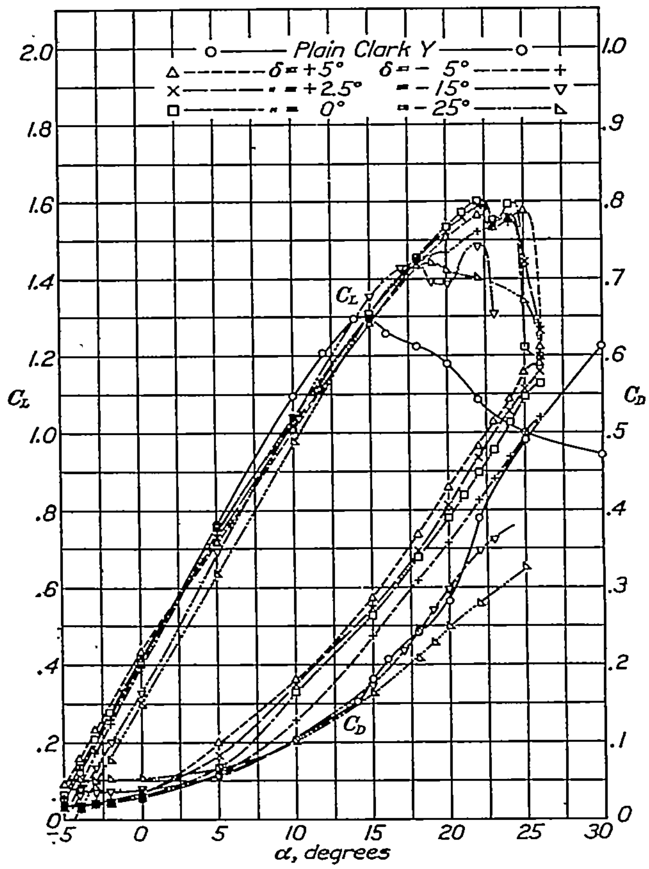


FIGURE 11.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 10 per cent chord ahead of leading edge and 15 per cent chord line of main wing

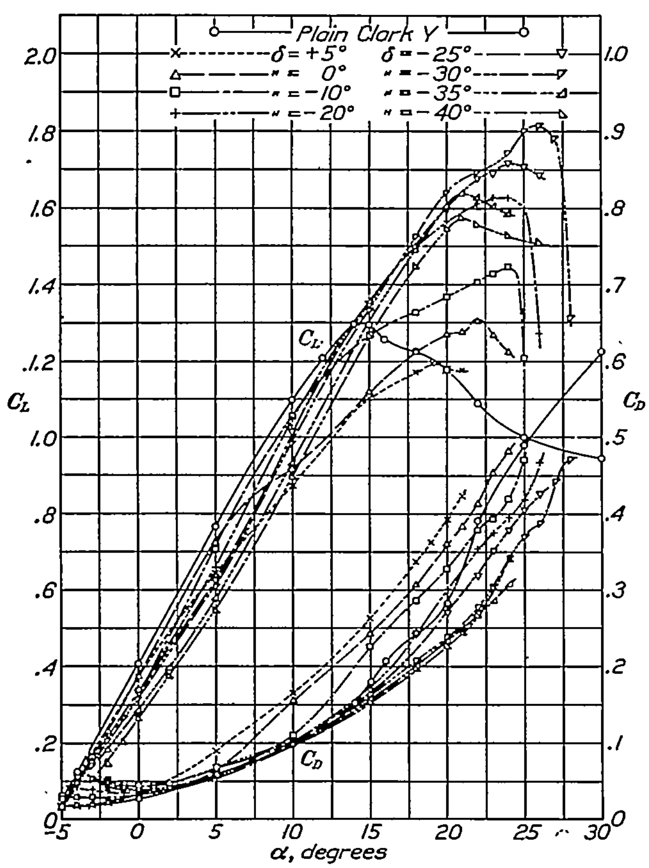


FIGURE 12.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 5 per cent chord ahead of leading edge and 6.5 per cent chord above chord line of main wing

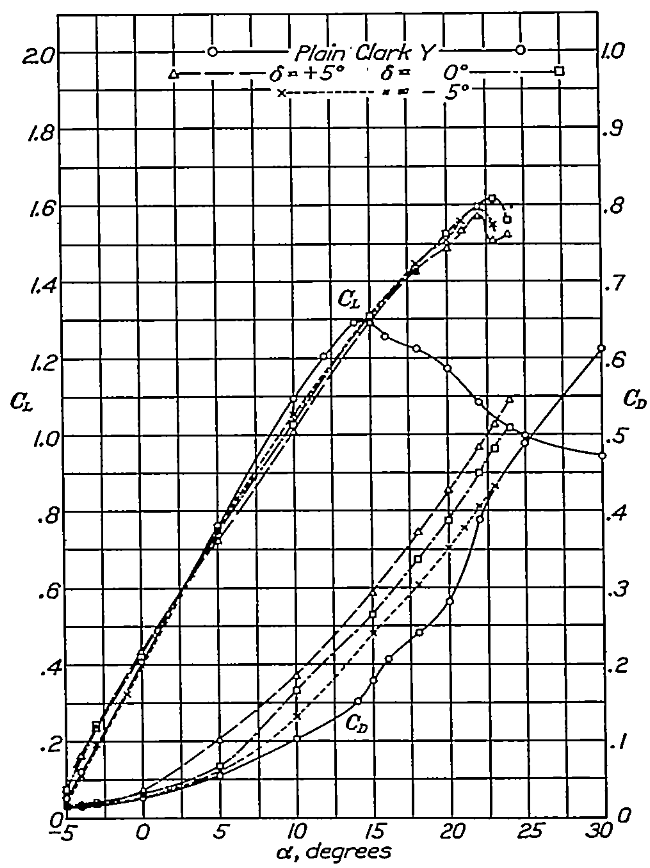


FIGURE 13.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 5 per cent chord ahead of leading edge and 21.5 per cent chord above chord line of main wing

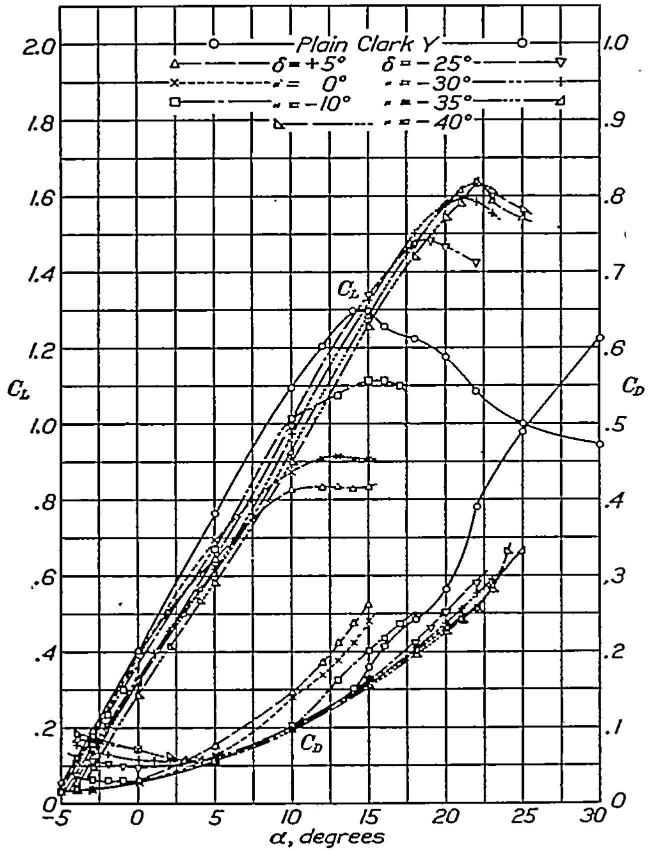


FIGURE 14.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 3 per cent chord ahead of leading edge and 4 per cent chord above chord line of main wing

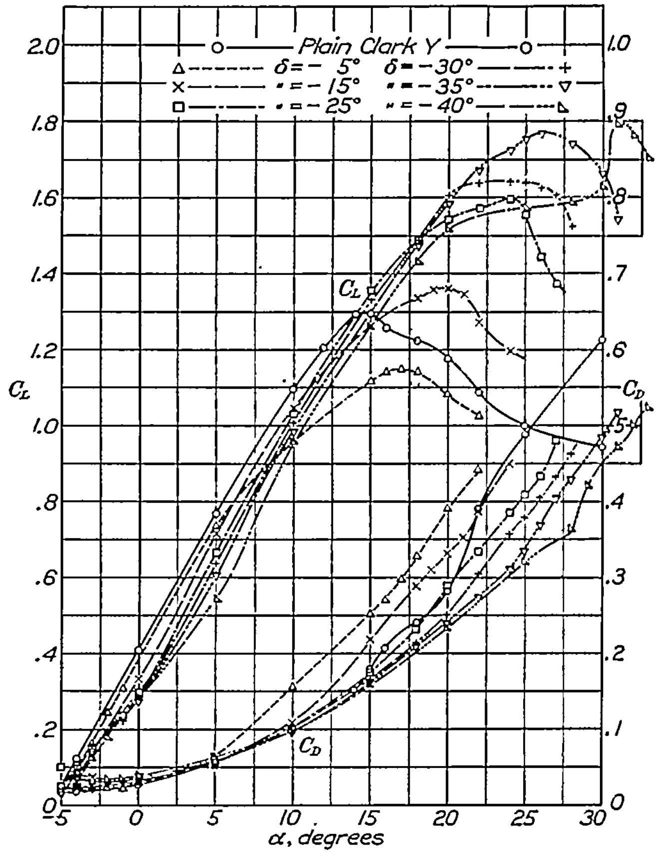


FIGURE 15.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 0 per cent chord ahead of leading edge and 10 per cent chord above chord line of main wing

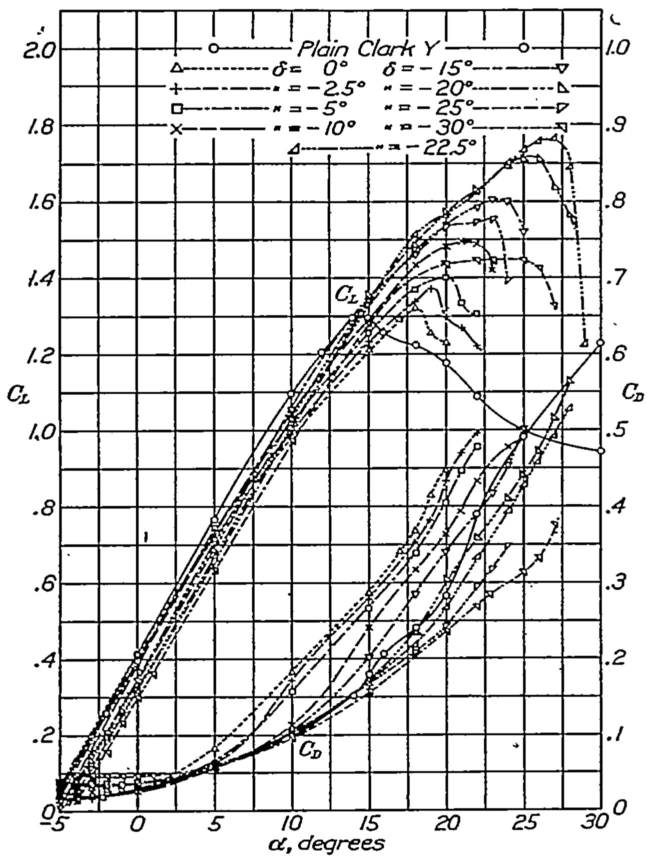


FIGURE 16.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 0 per cent chord ahead of leading edge and 15 per cent chord above chord line of main wing

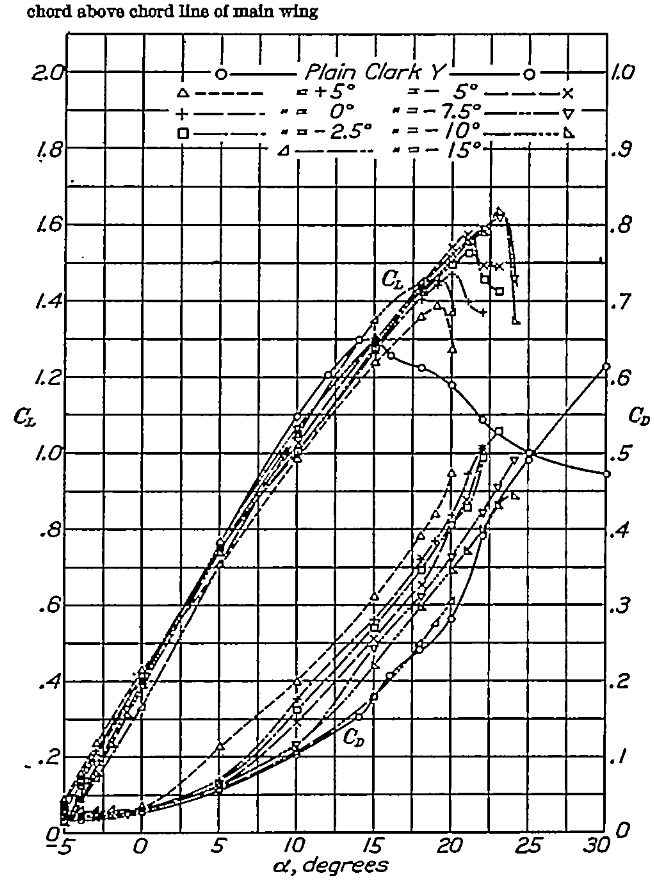


FIGURE 17.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 0 per cent chord ahead of leading edge and 20 per cent chord above chord line of main wing

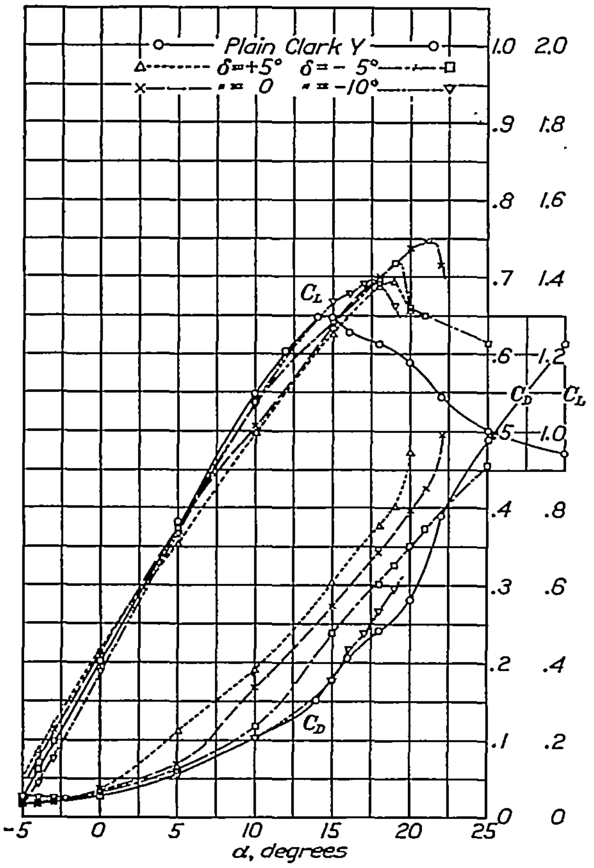


FIGURE 18.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 5 per cent chord behind leading edge and 24.8 per cent chord above chord line of main wing

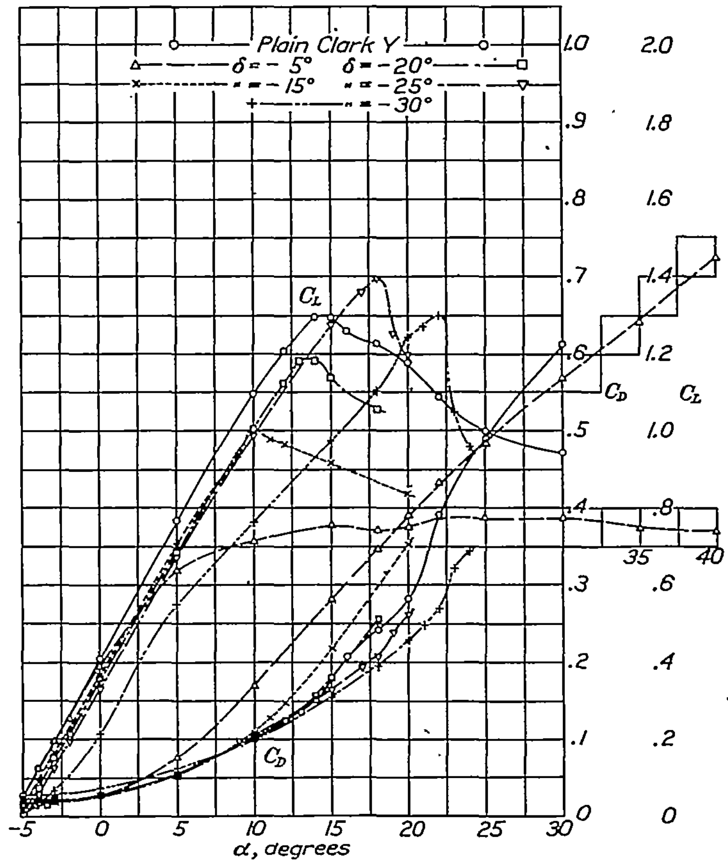


FIGURE 19.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 10 per cent chord behind leading edge and 12 per cent chord above chord line of main wing

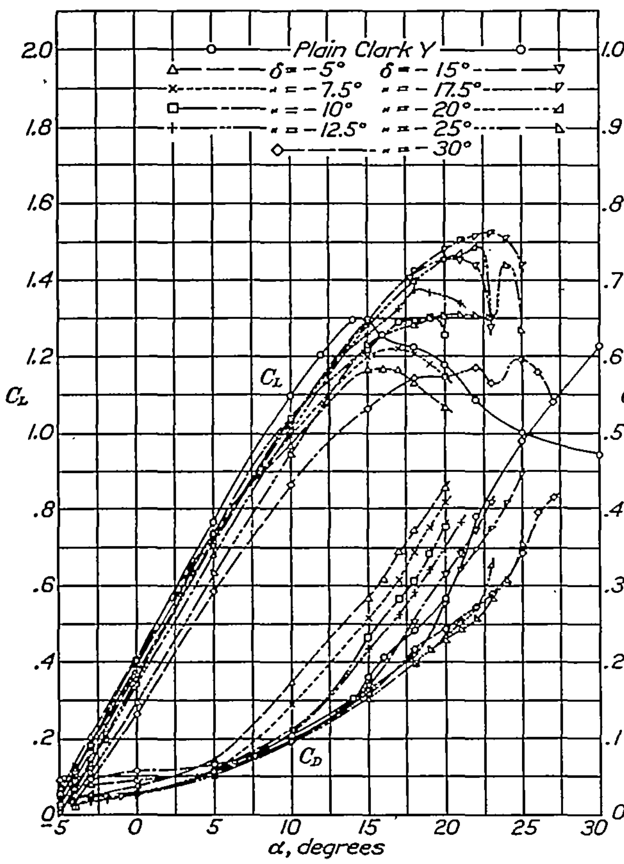


FIGURE 20.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 10 per cent chord behind leading edge and 17 per cent chord above chord line of main wing

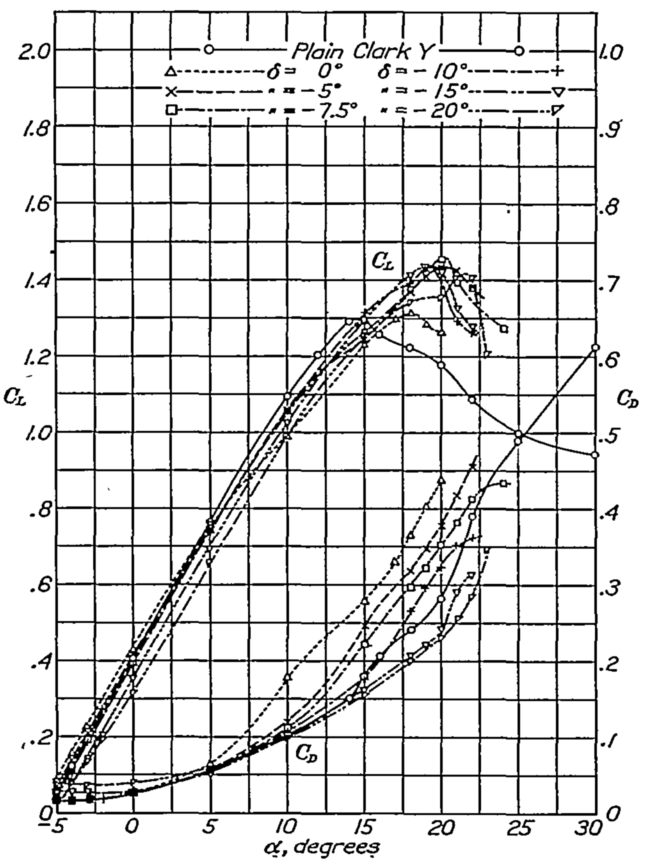


FIGURE 21.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 10 per cent chord behind leading edge and 22 per cent chord above chord line of main wing

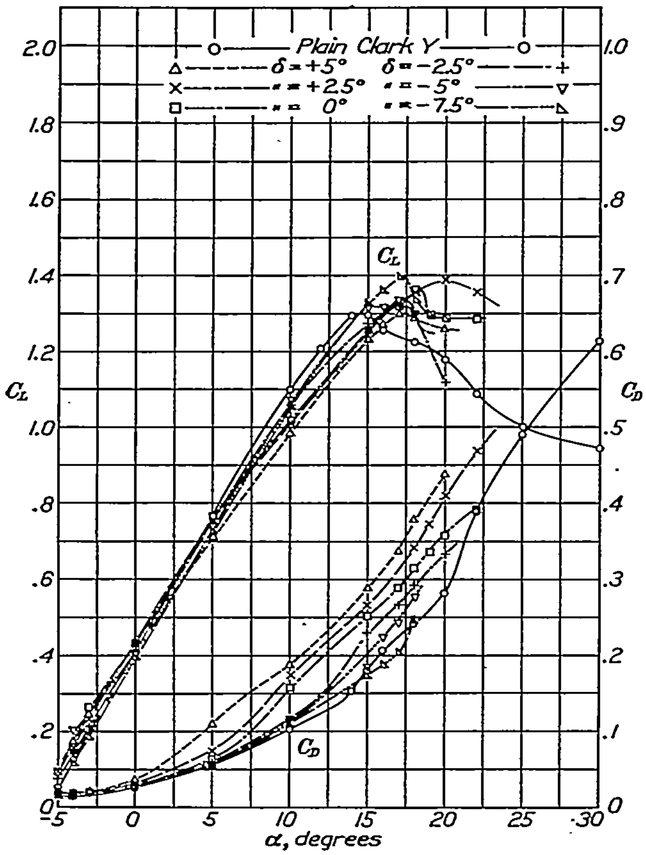


FIGURE 22.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 15 per cent chord behind leading edge and 28 per cent chord above chord line of main wing

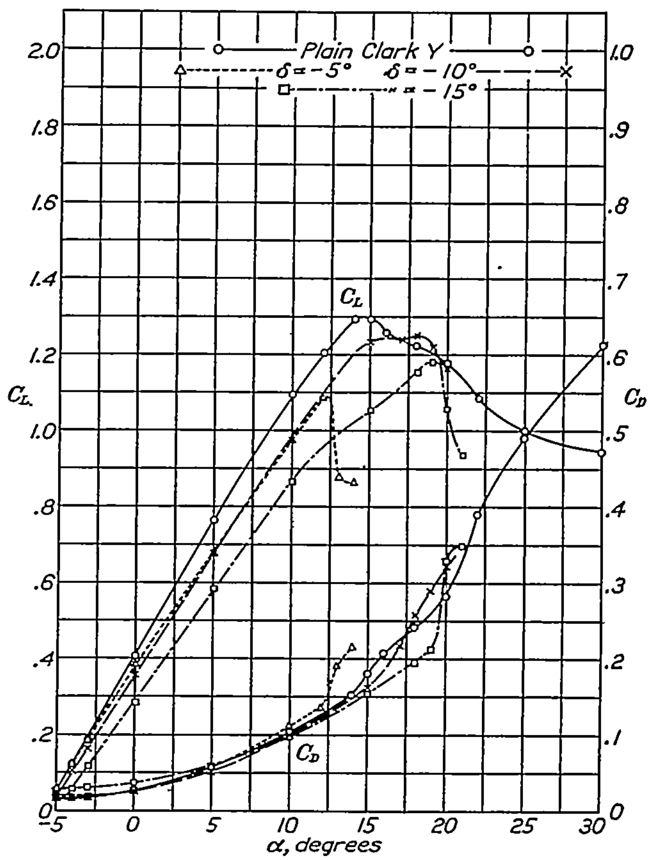


FIGURE 23.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 20 per cent chord behind leading edge and 14 per cent chord above chord line of main wing

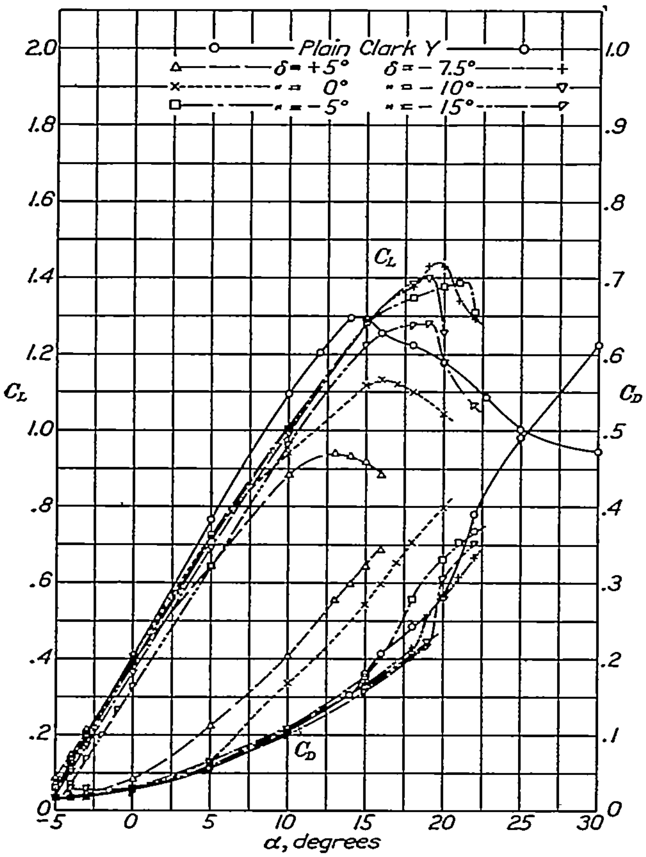


FIGURE 24.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 20 per cent chord behind leading edge and 19 per cent chord above chord line of main wing

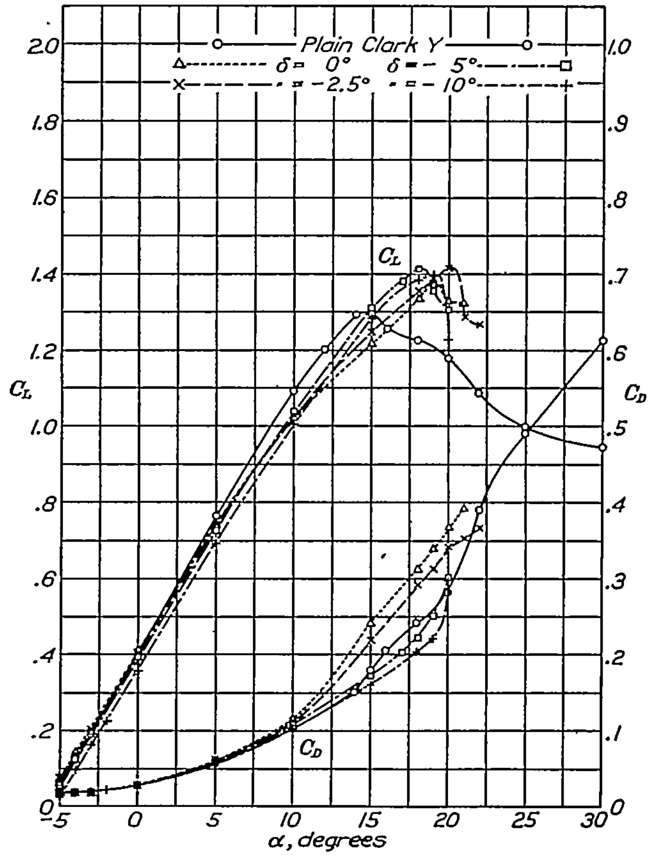


FIGURE 25.—Characteristics of combination of main and auxiliary wings with trailing edge of auxiliary 20 per cent chord behind leading edge and 24 per cent chord above chord line of main wing

The ratio $C_{L\max}/C_{D\min}$ is an indication of the suitability of a wing for giving a high speed range, and for a given minimum speed and total weight shows the relative merits of different wing arrangements in the high speed obtainable. A chart having contour lines for even values of the ratio $C_{L\max}/C_{D\min}$ is given in Figure 27. The maximum values of this ratio were obtained with the trailing edge of the auxiliary in the

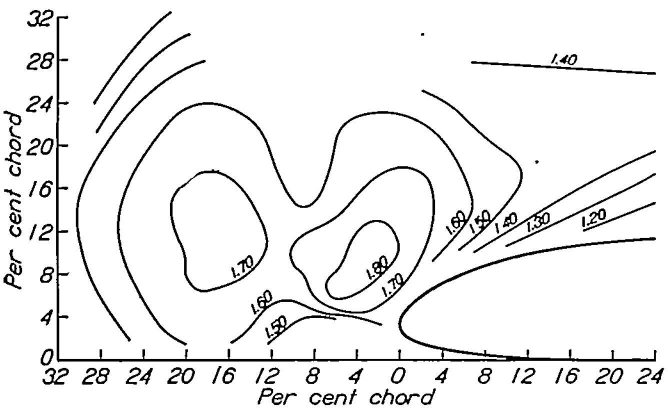


FIGURE 26.—Contours of equal values of $C_{L\max}$ obtained with various settings of trailing edge of auxiliary airfoil. The value at any point represents the maximum that can be obtained with any angular position

neighborhood of 17 per cent c ahead of the nose and 14 per cent c above the chord line of the main airfoil. The best location actually tested was that with the trailing edge of the auxiliary 15 per cent c ahead of the nose and 12 per cent c above the chord line, equal values being obtained with the chord of the auxiliary parallel to and at an angle of $+2.5°$ to the chord of the main wing. (This position, it will be noted, is in

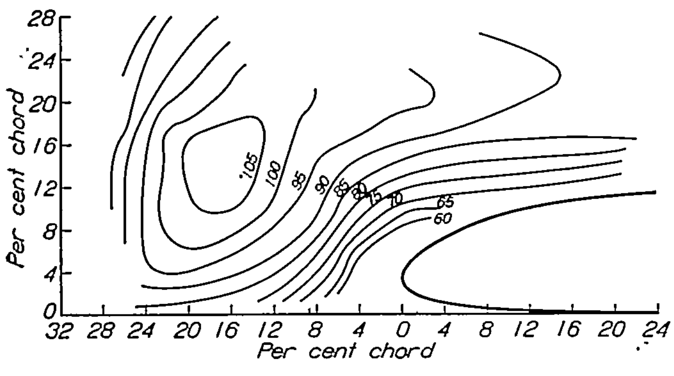


FIGURE 27.—Contours of equal values of $C_{L\max}/C_{D\min}$ obtained with various settings of trailing edge of auxiliary airfoil. The value at any point represents the maximum that can be obtained with any angular position

the second best region for high maximum lift coefficients.) The value of the ratio obtained at this point was 104.5, which is about 21 per cent higher than that for the main Clark Y wing alone (86.3) which seems remarkably fortunate considering that the maximum lift coefficient was 1.705 as compared with 1.295 for the main wing alone.

At the position which gave the highest value of $C_{L\max}$ actually tested (5 per cent c ahead of the nose, 6.5 per cent c above the main chord line, $\delta = -30°$), the ratio $C_{L\max}/C_{D\min}$ was 49.3—a value which would make the combination practically unusable if the auxiliary airfoil were fixed in position.

Selection of optimum position of auxiliary airfoil.—In the selection of the optimum position of the auxiliary airfoil with respect to the main wing, it is obviously advantageous to have a high value of the maximum lift coefficient, permitting the use of a relatively small wing with the lowest possible weight. It is also obviously an advantage to have the highest possible maximum speed with a given minimum and both of these points must be given consideration. The values of $C_{L\max}$ and $C_{L\max}/C_{D\min}$ given for any particular trailing-edge location in Figures 26 and 27 do not usually represent the same angular setting δ, which makes the actual selection of an optimum position rather complicated. One method of making

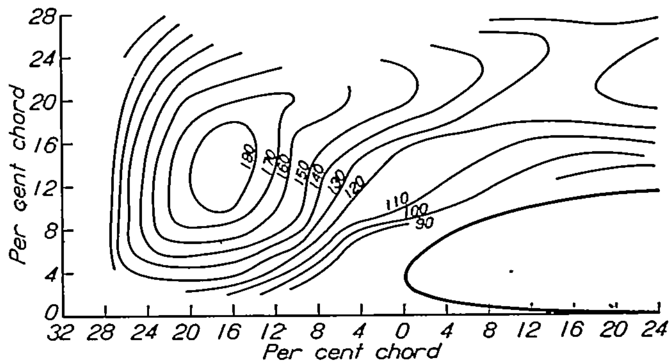


FIGURE 28.—Contours of equal values of $(C_{L\max})^2/C_{D\min}$ obtained with various settings of trailing edge of auxiliary airfoil. The value at any point represents the maximum that can be obtained with any angular position

such a selection is, of course, to base it on one's judgment, having studied the values for each position given in Table I. In order to facilitate this selection a criterion has been arbitrarily chosen which contains both $C_{L\max}$ and the ratio $C_{L\max}/C_{D\min}$ and gives them equal importance by taking the product of the two. The resulting criterion is the ratio $(C_{L\max})^2/C_{D\min}$.

The contours in Figure 28 represent the values of this ratio for the best angular setting δ at each location of the trailing edge of the auxiliary. On this basis the optimum location is about 17 per cent c ahead of the nose and 14 per cent c above the main chord line, which is the same as the location giving the highest value of $C_{L\max}/C_{D\min}$ and at the same time is in the second highest region for $C_{L\max}$. Of the points actually tested, that giving the highest ratio of $(C_{L\max})^2/C_{D\min}$ was 15 per cent c ahead of the nose and 12 per cent c above the chord line, the chord of the auxiliary being parallel to the chord of the main wing. A value very nearly as high was obtained with the same trailing-edge location and $\delta = +2.5°$. In either of these positions the angle of attack for the maximum lift coefficient was 24°, and the lift curve dropped sharply just above this point.

Curves of the center of pressure against angle of attack are given for values of δ of 0°, $+2.5°$, and $-5°$

for the optimum location of the trailing edge of the auxiliary, together with the lift and drag curves in Figure 7. The center of pressure in each case is practically constant at 20 per cent c back of the leading edge of the main wing for angles of attack from about 3° to that of the stall. At the stall the center of pressure goes suddenly back, giving a stable pitching moment. As the angle of attack is reduced below 3° the center of pressure travels back in the normal unstable direction, but at zero lift the unstable pitching moment is much less than that of the Clark Y wing alone. It is evident that an airplane with a wing and auxiliary airfoil in the optimum position would require a smaller horizontal tail plane to have satisfactory static longitudinal stability and balance at all angles of attack than the same airplane with the same main wing but without the auxiliary. In order to find whether this range of center-of-pressure travel was confined to one location of the auxiliary, the values were also measured for one other location that gave high values of maximum lift coefficient and speed-range ratio. For this position the trailing edge of the auxiliary was 15 per cent c ahead of the nose and 19.5 per cent c above the chord line and the chord of the auxiliary was parallel to the chord of the main wing. The center-of-pressure curve is given in Figure 8. The characteristics, it will be noted, are the same as for the other location of the auxiliary.

A matter deserving consideration in regard to the optimum position of the wing and auxiliary arrangement is the high value of the drag coefficient at the angle of attack for maximum lift. This high value makes possible steep glides, which are advantageous for making short landings. The value of L/D at maximum lift is only about 3.5 as compared with 8 for the Clark Y wing alone. These correspond to glide-path angles for the wings alone of 16° and 7°, respectively. Since the optimum combination of main wing and auxiliary has, in the climbing range, values of L/D ratio nearly as high as the Clark Y alone, the favorable characteristic of a high drag at the higher angles of attack is probably due to the stalling of the auxiliary airfoil.

Inasmuch as the first arbitrarily chosen combination of wing and auxiliary airfoil was found, when the auxiliary airfoil was put in the proper position, to give results substantially superior to those with single wings or previous combinations, it is very probable that still better combinations can be found. The present investigation should therefore be considered as only a beginning and should be followed by further tests with several carefully chosen airfoil sections, in which the best relative size of the main wing and auxiliary airfoil, as well as the best location in each case, are determined.

Comparison of optimum combination with slotted wings.—The earlier tests, including the best Handley Page type slot and the best fixed slot (references 1 and 2) developed with the same basic wing under the same test conditions, give an opportunity to compare directly the slots with the optimum combination of wing and auxiliary airfoil found in the present tests. The following table gives the data for the best combination in each set of tests as taken directly from the reports.

	$C_{D_{min}}$	$C_{L_{max}}$	α for $C_{L_{max}}$	$\frac{C_{L_{max}}}{C_{D_{min}}}$	$\frac{(C_{L_{max}})^2}{C_{D_{min}}}$
			°		
Clark Y wing alone	0.0150	1.295	15	86.3	111.9
Handley Page type automatic slot	[1] .0161	1.840	28	114.2	210
Fixed slot	.0229	1.751	24	76.4	134
Wing with auxiliary airfoil	[2] .0187	[2] 1.951	24	104.5	[2] 204

[1] Plain wing C_D increased 7.1 per cent to allow for imperfect form with slot closed. (Reference 5.)
[2] Coefficients based on area of main wing alone.

In the computation of these coefficients the area of the original wing, assuming the slot closed, was taken in the case of the Handley Page slot, although with the slot open the area was actually greater. The area of the original wing was used in the case of the fixed slot which was in effect merely cut through the original profile. The values for the wing with the auxiliary airfoil are therefore also based on the area of the main wing alone.

In order to enable a more accurate comparison to be made, the coefficients have been recomputed on the basis of the total wing area in each case, i. e., the area of the main wing plus the area of the auxiliary airfoil, or the slat, regardless of their positions with respect to each other. These recomputed coefficients are given in the following table.

	$C_{D_{min}}$	$C_{L_{max}}$	α for $C_{L_{max}}$	$\frac{C_{L_{max}}}{C_{D_{min}}}$	$\frac{(C_{L_{max}})^2}{C_{D_{min}}}$
			°		
Handley Page type automatic slot	0.0143	1.632	28	114.2	180.8
Fixed slot	.02155	1.648	24	76.4	126.1
Wing with auxiliary airfoil	.0163	1.705	24	104.5	178.3

On this basis the highest maximum lift coefficient was obtained with the wing and auxiliary airfoil of the present tests. The speed-range ratio is not quite so high as with the movable Handley Page type slot, but it is much higher for either of these than for the fixed slot or the plain Clark Y wing alone. The ratio $(C_{L_{max}})^2/C_{D_{min}}$ for determining the optimum combination gives the Handley Page slot a slight advantage, but for practical cases this might be insufficient to overcome the disadvantage of the extra mechanism required.

Effect of adding auxiliary airfoil to conventional monoplane.—To obtain the best results with a combination wing and auxiliary airfoil they should, of course, be incorporated while the airplane is in the design stage. It is interesting, however, to estimate the effect of merely adding an auxiliary airfoil to an average conventional monoplane. It will be assumed for simplicity that the gross weight remains unchanged and that the difference in balance can be taken care of by shifting the load forward. If the minimum gliding speed of the original airplane were 50 miles per hour and the maximum speed in level flight 115 miles per hour, the addition of the auxiliary airfoil in the optimum position would decrease the minimum speed to about 41 miles per hour and the maximum speed to 112 or 113 miles per hour. Also the airplane with the auxiliary airfoil could glide at a much steeper angle without stalling, and the original tail would give somewhat greater static stability than before. If a new wing without the auxiliary were supplied having the same total area and span as the original wing plus the auxiliary, a larger tail would be required to give the same stability, the minimum speed would be about 47 miles per hour, and the maximum speed about 113.

CONCLUSIONS

1. A position of the auxiliary wing with respect to the Clark Y main wing was found which gave a maximum lift coefficient of 1.81, 40 per cent greater than that for the Clark Y wing alone.

2. A range of positions of the auxiliary airfoil with respect to the main Clark Y wing was found which gave substantial gains in aerodynamic efficiency (effectiveness) as compared with that of the Clark Y wing alone. With the trailing edge of the auxiliary airfoil located 15 per cent of the chord of the main wing ahead of its leading edge and 12 per cent above the main chord line, and the chord lines parallel to each other, a value of the ratio $C_{L\max}/C_{D\min}$ of 104.5 was obtained, which is 21 per cent greater than that obtained for the Clark Y wing alone.

3. The optimum position tested, considering both $C_{L\max}$ and the ratio $C_{L\max}/C_{D\min}$ was the same as that giving the highest value of the ratio $C_{L\max}/C_{D\min}$. This position gave a maximum lift coefficient of 1.705 and a value of the ratio $C_{L\max}/C_{D\min}$ of 104.5, which are increases of 32 per cent and 21 per cent, respectively, over the values obtained with the Clark Y wing alone.

4. This investigation should be extended to include different sizes of the auxiliary airfoil with respect to the main wing and different airfoil sections, a sufficient number of relative positions being covered to determine the optimum with each combination.

Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., *February 23, 1932.*

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TABLE I

IMPORTANT AERODYNAMIC CHARACTERISTICS AND CRITERIONS OF A MAIN AND AUXILIARY WING COMBINATION FOR EACH TEST POSITION OF THE AUXILIARY

Position of trailing edge of auxiliary airfoil is measured in per cent chord ahead of leading edge and above chord line of main wing

δ is the angle between chord lines of main and auxiliary airfoils

Position of T. E. of auxiliary airfoil		δ	$C_{D_{min}}$	$C_{L_{max}}$	α for $C_{L_{max}}$	$\frac{C_{L_{max}}}{C_{D_{min}}}$	$\frac{C_{L_{max}}^2}{C_{D_{min}}}$
Ahead	Above						
		Degrees			*Degrees*		
Plain Clark Y.		----------	0.0150	1.295	15	86.3	111.9
25	6.5	−5	.0240	1.526	19	63.5	97.0
		0	.0191	1.590	21	83.2	132.2
		2.5	.0178	1.596	21	89.6	143.0
		5	.0173	1.588	21	91.7	145.7
25	13.0	0	.0179	1.480	19	82.6	122.2
		2.5	.0178	1.598	21	89.6	143.1
		5	.0175	1.600	21	91.5	146.2
		7.5	.0195	1.635	22	83.8	137.0
		10	.0219	1.611	22	73.7	118.9
25	19.5	0	.0179	1.390	18	77.7	108.0
		5	.0173	1.511	20	87.3	132.2
		7.5	.0191	1.571	21	82.2	129.3
		10	.0199	1.563	21	78.5	123.0
25	27.0	−5	.0224	1.342	16	60.0	80.5
		0	.0176	1.342	16	76.3	102.5
		2.5	.0183	1.360	17	74.2	101.0
		5	.0189	1.380	17	73.0	100.8
15	4.5	−20	.0446	1.440	18	32.3	46.5
		−15	.0368	1.619	21	44.0	71.2
		−12.5	.0352	1.652	22	46.9	77.7
		−10	.0319	1.602	21	50.2	80.5
		0	.0168	1.495	20	88.9	133.0
		2.5	.0161	1.475	20	91.6	135.0
		5	.0161	1.448	20	89.8	130.1
15	12.0	−15	.0367	1.443	17	39.4	56.8
		−10	.0316	1.608	21	50.8	81.8
		−5	.0222	1.718	24	77.3	132.8
		−2.5	.0191	1.722	24	90.2	155.2
		0	.0163	1.705	24	104.5	178.3
		2.5	.0163	1.702	24	104.5	178.0
		5	.0174	1.677	24	96.2	161.3
15	19.5	−10	.0298	1.399	18	46.9	65.5
		−5	.0222	1.440	19	65.0	93.5
		0	.0161	1.662	23	103.2	172.0
		2.5	.0166	1.662	23	100.2	166.3
		5	.0191	1.661	23	87.0	144.8
10	5.0	−25	.0424	1.490	19	35.1	52.4
		−20	.0398	1.558	23	39.1	60.9
		−15	.0368	1.572	21	42.7	67.2
		−10	.0319	1.500	21	47.0	70.5
		−5	.0240	1.458	21	60.7	88.5
		0	.0169	1.388	20	82.1	114.0
		2.5	.0161	1.360	20	84.5	115.0
		5	.0166	1.321	20	79.6	105.2
10	10.0	−25	.0320	1.500	19	46.8	70.3
		−15	.0304	1.690	23	55.6	94.0
		−12.5	.0298	1.702	24	57.2	97.5
		−10	.0300	1.702	24	56.8	96.6
		−5	.0215	1.640	23	76.3	125.1
		−2.5	.0179	1.606	23	89.8	144.1
		0	.0169	1.601	23	94.8	152.0
		2.5	.0176	1.578	23	89.5	141.0
		5	.0183	1.529	22	83.9	128.4
10	15.0	−25	.0503	1.440	19	28.6	41.2
		−15	.0327	1.438	18	44.0	63.3
		−5	.0194	1.550	24	80.0	124.0
		0	.0164	1.600	22	97.5	156.0
		2.5	.0161	1.592	22	98.8	157.5
		5	.0166	1.563	22	94.5	148.1
5	6.5	−40	.0432	1.572	21	36.4	57.3
		−35	.0401	1.639	21	40.8	67.0
		−30	.0367	1.812	26	49.3	89.5
		−25	.0355	1.718	24	48.3	83.1
		−20	.0336	1.625	24	48.3	78.6
		−10	.0288	1.446	24	50.2	72.6
		0	.0191	1.308	22	68.4	89.5
		5	.0186	1.192	19	64.2	76.5
5	21.5	−5	.0191	1.593	22	83.4	133.0
		0	.0163	1.612	23	98.8	159.7
		5	.0184	1.572	22	85.4	134.2

Position of T. E. of auxiliary airfoil		δ	$C_{D_{min}}$	$C_{L_{max}}$	α for $C_{L_{max}}$	$\frac{C_{L_{max}}}{C_{D_{min}}}$	$\frac{C_{L_{max}}^2}{C_{D_{min}}}$
Ahead	Above						
		Degrees			*Degrees*		
3	4.0	−40	0.0593	1.630	22	27.5	44.7
		−35	.0589	1.638	22	27.8	45.5
		−30	.0566	1.593	21	28.2	44.9
		−25	.0463	1.482	19	32.0	47.5
		−10	.0302	1.118	15	37.0	41.3
		0	.0191	.915	13	48.0	44.0
		5	.0172	.838	13	48.7	40.8
0	10.0	−40	.0334	1.800	31	53.8	97.0
		−35	.0292	1.768	27	60.5	107.0
		−30	.0245	1.645	24	67.1	110.5
		−25	.0238	1.598	24	67.1	107.1
		−15	.0215	1.360	20	63.2	80.0
		−5	.0207	1.149	17	55.5	63.7
0	15.0	−30	.0442	1.443	23	32.7	47.2
		−25	.0358	1.555	23	43.4	67.5
		−22.5	.0339	1.766	27	52.1	92.0
		−20	.0296	1.710	26	57.8	98.8
		−15	.0258	1.602	23	62.1	99.5
		−10	.0225	1.498	21	66.6	99.8
		−5	.0179	1.400	20	78.2	109.5
		−2.5	.0158	1.370	19	86.7	118.8
		0	.0166	1.322	18	79.7	105.4
0	20.0	−15	.0279	1.460	19	52.4	70.5
		−10	.0233	1.630	23	70.0	114.2
		−7.5	.0202	1.620	23	80.4	130.2
		−5	.0164	1.574	21	96.0	151.0
		−2.5	.0161	1.526	21	94.8	144.8
		0	.0168	1.468	20	87.3	128.1
		5	.0167	1.382	19	82.8	114.4
−5	24.8	−10	.0240	1.382	18	57.7	79.8
		−5	.0166	1.432	19	86.3	123.0
		0	.0163	1.493	21	91.6	137.0
		5	.0181	1.388	19	76.7	100.2
−10	12.0	−30	.0216	1.300	22	60.2	78.3
		−25	.0201	1.392	18	69.3	96.5
		−20	.0171	1.180	14	69.0	81.5
		−15	.0173	1.008	10	58.2	58.6
		−5	.0168	.778	25	46.3	30.0
−10	17.0	−30	.0458	1.191	25	26.0	31.0
		−25	.0392	1.308	22	33.3	43.5
		−20	.0278	1.485	22	53.3	70.3
		−17.5	.0242	1.526	23	63.1	90.4
		−15	.0198	1.452	21	73.3	106.8
		−12.5	.0176	1.372	18	78.0	107.1
		−10	.0150	1.300	19	86.7	112.8
		−7.5	.0158	1.222	17	77.4	94.0
		−5	.0262	1.168	17	44.5	52.0
−10	22.0	−20	.0364	1.408	22	38.6	54.4
		−15	.0265	1.432	19	54.1	77.5
		−10	.0181	1.430	19	79.0	113.0
		−7.5	.0161	1.455	20	90.4	131.5
		−5	.0158	1.432	20	90.7	130.0
		0	.0160	1.315	18	82.2	108.0
−15	28.0	−7.5	.0178	1.398	17	78.5	109.8
		−5	.0158	1.332	17	84.3	112.2
		−2.5	.0161	1.320	17	82.4	108.9
		0	.0158	1.360	18	86.0	117.0
		2.5	.0174	1.381	20	79.3	109.8
		5	.0176	1.300	17	73.8	96.0
−20	14.0	−15	.0252	1.181	19	46.9	55.5
		−10	.0168	1.250	18	74.4	93.0
		−5	.0158	1.088	12	68.8	74.8
−20	19.0	−15	.0268	1.281	19	47.8	61.3
		−10	.0166	1.400	19	84.2	118.0
		−7.5	.0161	1.432	20	89.0	127.5
		−5	.0163	1.388	21	85.0	118.0
		0	.0161	1.135	16	70.5	80.0
		5	.0173	.941	13	54.4	51.2
−20	24.0	−10	.0199	1.398	19	70.3	98.3
		−5	.0163	1.412	18	86.5	122.0
		−2.5	.0158	1.416	20	89.5	126.8
		0	.0161	1.371	19	85.2	117.0